RYA-129/DIV

Patent Application

of

Stephen J. Brown

for

NETWORKED SYSTEM FOR INTERACTIVE COMMUNICATION AND REMOTE MONITORING OF INDIVIDUALS

RELATED APPLICATION INFORMATION

This application is a divisional application of application Ser. No. 08/946,341 filed October 7, 1997, now U.S. Patent No. 5,997,476 which is a continuation-in-part of application Ser. No. 08/847,009 filed April 30, 1997, now U.S. Patent No. 5,897,493. This application also claims priority from provisional application Ser. No. 60/041,746 filed March 28, 1997 and from provisional application Ser. No. 60/041,751 filed March 28, 1997. This application also claims priority from application Ser. No. 09/201,323 entitled "Leveraging Interactions with a Community of Individuals", filed November 30, 1998 and from application Ser. No, 09/274,433 entitled "Client-Initiated Leveraged Interaction with Providers", filed March 22, 1999. All of the above named applications are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to communication systems for remote monitoring of individuals, and in particular to a networked system for remotely monitoring individuals and for communicating information to the individuals through the use script programs.

BACKGROUND OF THE INVENTION

In the United States alone, over 100 million people have chronic health conditions, accounting for an estimated $700 billion in annual medical costs. In an effort to control these medical costs, many healthcare providers have initiated outpatient or home healthcare programs for their patients. The potential benefits of these programs are particularly great for chronically ill patients who must treat their diseases on a daily basis. However, the success of these programs is dependent upon the ability of the healthcare providers to monitor the patients remotely to avert medical problems before they become complicated and costly. Unfortunately, no convenient and cost effective monitoring system exists for the patients who have the greatest need for monitoring, the poor and the elderly.

Prior attempts to monitor patients remotely have included the use of personal computers and modems to establish communication between patients and healthcare providers. However, computers are too expensive to give away and the patients who already own computers are only a small fraction of the total population. Further, the patients who own computers are typically young, well educated, and have good healthcare coverage. Thus, these patients do not have the greatest unmet medical needs. The patients who have the greatest unmet medical needs are the poor and elderly who do not own computers or who are unfamiliar with their use.

Similar attempts to establish communication between patients and healthcare providers have included the use of the Internet and internet terminals. Although internet terminals are somewhat less costly than personal computers, they are still too expensive to give away to patients. Moreover,

monthly on-line access charges are prohibitive for poor patients.

Other attempts to monitor patients remotely have included the use of medical monitoring devices with built-in modems. Examples of such monitoring devices include blood glucose meters, respiratory flow meters, and heart rate monitors. Unfortunately, these monitoring devices are only designed to collect physiological data from the patients. They do not allow flexible and dynamic querying of the patients for other information, such as quality of life measures or psycho-social variables of illness.

Prior attempts to monitor patients remotely have also included the use of interactive telephone or video response systems. Such interactive systems are disclosed in U.S. Patents 5,390,238 issued to Kirk et al. on February 14, 1995, 5,434,611 issued to Tamura on July 18, 1995, and 5,441,047 issued to David et al. on August 15, 1995. One disadvantage of these systems is that they either require a patient to call in to a central facility to be monitored or require the central facility to call the patient according to a rigid monitoring schedule.

If the patients are required to call the central facility, only the compliant patients will actually call regularly to be monitored. Non-compliant patients will typically wait until an emergency situation develops before contacting their healthcare provider, thus defeating the purpose of the monitoring system. If the central facility calls each patient according to a monitoring schedule, it is intrusive to the patient's life and resistance to the monitoring grows over time.

Another disadvantage of these conventional interactive response systems is that they are prohibitively expensive for poor patients. Further, it is difficult to identify each patient uniquely using these systems. Moreover, these systems are generally incapable of collecting medical data from monitoring devices, such as blood glucose meters, respiratory flow meters, or heart rate monitors.

OBJECTS AND ADVANTAGES OF THE INVENTION

In view of the above, it is an object of the present invention to provide a simple and inexpensive system for remotely monitoring patients and for communicating information to the patients. It is another object of the invention to provide a system which allows flexible and dynamic querying of the patients. It is a further object of the invention to provide a system which combines querying of patients with medical device monitoring in the same monitoring session. Another object of the invention is to provide a monitoring system which incurs lower communications charges than those incurred by conventional monitoring systems. A further object of the invention is to provide a monitoring system which may be used at any time convenient for a patient.

These and other objects and advantages will become more apparent after consideration of the ensuing description and the accompanying drawings.

SUMMARY

The invention presents a networked system for remotely monitoring an individual and for communicating information to the individual. The system includes a server and a remote interface for entering in the server a set of queries to be

answered by the individual. The server is preferably a world wide web server and the remote interface is preferably a personal computer or network terminal connected to the web server via the Internet. The system also includes a remotely programmable apparatus for interacting with the individual. The apparatus is connected to the server via a communication network, preferably the Internet. The apparatus interacts with the individual in accordance with a script program received from the server.

The server includes a script generator for generating the script program from the queries entered through the remote interface. The script program is executable by the apparatus to communicate the queries to the individual, to receive responses to the queries, and to transmit the responses from the apparatus to the server. The server also includes a database connected to the script generator for storing the script program and the responses to the queries.

The apparatus has a communication device, such as a modem, for receiving the script program from the server and for transmitting the responses to the server. The apparatus also has a user interface for communicating the queries to the individual and for receiving the responses to the queries. In the preferred embodiment, the user interface includes a display for displaying the queries and user input buttons for entering the responses to the queries. In an alternative embodiment, the user interface includes a speech synthesizer for audibly communicating the queries and a speech recognizer for receiving spoken responses to the queries.

The apparatus also includes a memory for storing the script program and the responses to the queries. The apparatus further includes a microprocessor connected to the communication device, the user interface, and the memory.

The microprocessor executes the script program to communicate the queries to the individual, to receive the responses to the queries, and to transmit the responses to the server through the communication network.

In the preferred embodiment, the system also includes at least one monitoring device for producing measurements of a physiological condition of the individual and for transmitting the measurements to the apparatus. The apparatus further includes a device interface connected to the microprocessor for receiving the measurements from the monitoring device. The measurements are stored in the memory and transmitted to the server with the responses to the queries. The server also preferably includes a report generator connected to the database for generating a report of the measurements and responses. The report is displayed on the remote interface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a networked system according to a preferred embodiment of the invention.

FIG. 2 is a block diagram illustrating the interaction of the components of the system of FIG. 1.

FIG. 3 is a perspective view of a remotely programmable apparatus of the system of FIG. 1.

FIG. 4 is a block diagram illustrating the components of the apparatus of FIG. 3.

FIG. 5 is a script entry screen according to the preferred embodiment of the invention.

FIG. 6A is a listing of a sample script program according to the preferred embodiment of the invention.

FIG. 6B is a continuation of the listing of FIG. 6A.

FIG. 7 is a script assignment screen according to the preferred embodiment of the invention.

FIG. 8 is a sample query appearing on a display of the apparatus of FIG. 3.

FIG. 9 is a sample prompt appearing on the display of the apparatus of FIG. 3.

FIG. 10 is a sample report displayed on a workstation of the system of FIG. 1.

FIG. 11A is a flow chart illustrating the steps included in a monitoring application executed by the server of FIG. 1 according to the preferred embodiment of the invention.

FIG. 11B is a continuation of the flow chart of FIG. 11A.

FIG. 12A is a flow chart illustrating the steps included in the script program of FIGS. 6A - 6B.

FIG. 12B is a continuation of the flow chart of FIG. 12A.

FIG. 13 is a perspective view of a remotely programmable apparatus according to a second embodiment of the invention.

FIG. 14 is a sample prompt appearing on a display of the apparatus of FIG. 13.

FIG. 15 is a block diagram illustrating the components of the apparatus of FIG. 13.

FIG. 16 is a schematic block diagram illustrating the interaction of the server of FIG. 1 with the apparatus of FIG. 3 according to a third embodiment of the invention.

FIG. 17 is a first sample message appearing on the display of the apparatus of FIG. 3.

FIG. 18 is a second sample message appearing on the display of the apparatus of FIG. 3.

FIG. 19 is a script entry screen according to the third embodiment of the invention.

DETAILED DESCRIPTION

The invention presents a system and method for remotely monitoring individuals and for communicating information to the individuals. In a preferred embodiment of the invention, the individuals are patients and the system is used to collect data relating to the health status of the patients. However, it is to be understood that the invention is not limited to remote patient monitoring. The system and method of the invention may be used for any type of remote monitoring application. The invention may also be implemented as an automated messaging system for communicating information to individuals, as will be discussed in an alternative embodiment below.

A preferred embodiment of the invention is illustrated in FIGS. 1 - 12. Referring to FIG. 1, a networked system **16** includes a server **18** and a workstation **20** connected to server **18** through a communication network **24**. Server **18** is preferably a world wide web server and communication network **24** is preferably the Internet. It will be apparent to one skilled in the art that server **18** may comprise a single stand-alone computer or multiple computers distributed throughout a network. Workstation **20** is preferably a personal computer, remote terminal, or web TV unit connected to server **18** via the Internet. Workstation **20** functions as a remote interface for entering in server **18** messages and queries to be communicated to the patients.

System **16** also includes first and second remotely programmable apparatuses **26** and **32** for monitoring first and second patients, respectively. Each apparatus is designed to interact with a patient in accordance with script programs received from server **18**. Each apparatus is in communication with server **18** through communication network **24**, preferably the Internet. Alternatively, each apparatus may be placed in communication with server **18** via wireless communication

networks, cellular networks, telephone networks, or any other network which allows each apparatus to exchange data with server **18**. For clarity of illustration, only two apparatuses are shown in FIG. 1. It is to be understood that system **16** may include any number of apparatuses for monitoring any number of patients.

In the preferred embodiment, each patient to be monitored is also provided with a monitoring device **28**. Monitoring device **28** is designed to produce measurements of a physiological condition of the patient, record the measurements, and transmit the measurements to the patient's apparatus through a standard connection cable **30**. Examples of suitable monitoring devices include blood glucose meters, respiratory flow meters, blood pressure cuffs, electronic weight scales, and pulse rate monitors. Such monitoring devices are well known in the art. The specific type of monitoring device provided to each patient is dependent upon the patient's disease. For example, diabetes patients are provided with a blood glucose meters for measuring blood glucose concentrations, asthma patients are provided with respiratory flow meters for measuring peak flow rates, obesity patients are provided with weight scales, etc.

FIG. 2 shows server **18**, workstation **20**, and apparatus **26** in greater detail. Server **18** includes a database **38** for storing script programs **40**. The script programs are executed by each apparatus to communicate queries and messages to a patient, receive responses **42** to the queries, collect monitoring device measurements **44**, and transmit responses **42** and measurements **44** to server **18**. Database **38** is designed to store the responses **42** and measurements **44**. Database **38** further includes a look-up table **46**. Table **46** contains a list of the patients to be monitored, and for each patient, a unique patient identification code and a respective pointer

to the script program assigned to the patient. Each remote apparatus is designed to execute assigned script programs which it receives from server **18**.

FIGS. 3 - 4 show the structure of each apparatus according to the preferred embodiment. For clarity, only apparatus **26** is shown since each apparatus of the preferred embodiment has substantially identical structure to apparatus **26**. Referring to FIG. 3, apparatus **26** includes a housing **62**. Housing **62** is sufficiently compact to enable apparatus **26** to be hand-held and carried by a patient. Apparatus **26** also includes a display **64** for displaying queries and prompts to the patient. In the preferred embodiment, display **64** is a liquid crystal display (LCD).

Four user input buttons **70A**, **70B**, **70C**, and **70D** are located adjacent display **64**. The user input buttons are for entering in apparatus **26** responses to the queries and prompts. In the preferred embodiment, the user input buttons are momentary contact push buttons. In alternative embodiments, the user input buttons may be replaced by switches, keys, a touch sensitive display screen, or any other data input device.

Three monitoring device jacks **68A**, **68B**, and **68C** are located on a surface of housing **62**. The device jacks are for connecting apparatus **26** to a number of monitoring devices, such as blood glucose meters, respiratory flow meters, or blood pressure cuffs, through respective connection cables (not shown). Apparatus **26** also includes a modem jack **66** for connecting apparatus **26** to a telephone jack through a standard connection cord (not shown). Apparatus **26** further includes a visual indicator, such as a light emitting diode (LED) **74**. LED **74** is for visually notifying the patient that he or she has unanswered queries stored in apparatus **26**.

FIG. 4 is a schematic block diagram illustrating the components of apparatus **26** in greater detail. Apparatus **26** includes a microprocessor **76** and a memory **80** connected to microprocessor **76**. Memory **80** is preferably a non-volatile memory, such as a serial EEPROM. Memory **80** stores script programs received from the server, measurements received from monitoring device **28**, responses to queries, and the patient's unique identification code. Microprocessor **76** also includes built-in read only memory (ROM) which stores firmware for controlling the operation of apparatus **26**. The firmware includes a script interpreter used by microprocessor **76** to execute the script programs. The script interpreter interprets script commands which are executed by microprocessor **76**. Specific techniques for interpreting and executing script commands in this manner are well known in the art.

Microprocessor **76** is preferably connected to memory **80** using a standard two-wire I^2C interface. Microprocessor **76** is also connected to user input buttons **70**, LED **74**, a clock **84**, and a display driver **82**. Clock **84** indicates the current date and time to microprocessor **76**. For clarity of illustration, clock **84** is shown as a separate component, but is preferably built into microprocessor **76**. Display driver **82** operates under the control of microprocessor **76** to display information on display **64**. Microprocessor **76** is preferably a PIC 16C65 processor which includes a universal asynchronous receiver transmitter (UART) **78**. UART **78** is for communicating with a modem **86** and a device interface **90**. A CMOS switch **88** under the control of microprocessor **76** alternately connects modem **86** and interface **90** to UART **78**.

Modem **86** is connected to a telephone jack **22** through modem jack **66**. Modem **86** is for exchanging data with server **18** through communication network **24**. The data includes script

programs which are received from the server as well as responses to queries, device measurements, script identification codes, and the patient's unique identification code which modem **86** transmits to the server. Modem **86** is preferably a complete 28.8 K modem commercially available from Cermetek, although any suitable modem may be used.

Device interface **90** is connected to device jacks **68A**, **68B**, and **68C**. Device interface **90** is for interfacing with a number of monitoring devices, such as blood glucose meters, respiratory flow meters, blood pressure cuffs, weight scales, or pulse rate monitors, through the device jacks. Device interface **90** operates under the control of microprocessor **76** to collect measurements from the monitoring devices and to output the measurements to microprocessor **76** for storage in memory **80**. In the preferred embodiment, interface **90** is a standard RS232 interface. For simplicity of illustration, only one device interface is shown in FIG. 4. However, in alternative embodiments, apparatus **26** may include multiple device interfaces to accommodate monitoring devices which have different connection standards.

Referring again to FIG. 2, server **18** includes a monitoring application **48**. Monitoring application **48** is a controlling software application executed by server **18** to perform the various functions described below. Application **48** includes a script generator **50**, a script assignor **52**, and a report generator **54**. Script generator **50** is designed to generate script programs **40** from script information entered through workstation **20**. The script information is entered through a script entry screen **56**. In the preferred embodiment, script entry screen **56** is implemented as a web page on server **18**. Workstation **20** includes a web browser for accessing the web page to enter the script information.

FIG. 5 illustrates script entry screen **56** as it appears on workstation **20**. Screen **56** includes a script name field **92** for specifying the name of a script program to be generated. Screen **56** also includes entry fields **94** for entering a set of queries to be answered by a patient. Each entry field **94** has corresponding response choice fields **96** for entering response choices for the query. Screen **56** further includes check boxes **98** for selecting a desired monitoring device from which to collect measurements, such as a blood glucose meter, respiratory flow meter, or blood pressure cuff.

Screen **56** additionally includes a connection time field **100** for specifying a prescribed connection time at which each apparatus executing the script is to establish a subsequent communication link to the server. The connection time is preferably selected to be the time at which communication rates are the lowest, such as 3:00 AM. Screen **56** also includes a CREATE SCRIPT button **102** for instructing the script generator to generate a script program from the information entered in screen **56**. Screen **56** further includes a CANCEL button **104** for canceling the information entered in screen **56**.

In the preferred embodiment, each script program created by the script generator conforms to the standard file format used on UNIX systems. In the standard file format, each command is listed in the upper case and followed by a colon. Every line in the script program is terminated by a linefeed character {LF}, and only one command is placed on each line. The last character in the script program is a UNIX end of file character {EOF}. Table 1 shows an exemplary listing of script commands used in the preferred embodiment of the invention.

TABLE 1 - SCRIPT COMMANDS

Command	Description
CLS: {LF}	Clear the display.
ZAP: {LF}	Erase from memory the last set of query responses recorded.
LED: b{LF}	Turn the LED on or off, where b is a binary digit of 0 or 1. An argument of 1 turns on the LED, and an argument of 0 turns off the LED.
DISPLAY: {chars}{LF}	Display the text following the DISPLAY command.
INPUT: mmmm{LF}	Record a button press. The m's represent a button mask pattern for each of the four input buttons. Each m contains an "X" for disallowed buttons or an "O" for allowed buttons. For example, INPUT: OXOX{LF} allows the user to press either button #1 or #3.
WAIT: {LF}	Wait for any one button to be pressed, then continue executing the script program.
COLLECT: device{LF}	Collect measurements from the monitoring device specified in the COLLECT command. The user is preferably prompted to connect the specified monitoring device to the apparatus and press a button to continue.
NUMBER: aaaa{LF}	Assign a script identification code to the script program. The script identification code from the most recently executed NUMBER statement is subsequently transmitted to the server along with the query responses and device measurements. The script identification code identifies to the server which script program was most recently executed by the remote apparatus.
DELAY: t {LF}	Wait until time t specified in the DELAY command, usually the prescribed connection time.
CONNECT: {LF}	Perform a connection routine to establish a communication link to the server, transmit the patient identification code, query responses, device measurements, and script identification code to the server, and receive and store a new script program. When the server instructs the apparatus to disconnect, the script interpreter is restarted, allowing the new script program to execute.

The script commands illustrated in Table 1 are representative of the preferred embodiment and are not intended to limit the scope of the invention. After consideration of the ensuing description, it will be apparent to one skilled in the art many other suitable scripting languages and sets of script commands may be used to implement the invention.

Script generator **50** preferably stores a script program template which it uses to create each script program. To generate a script program, script generator **50** inserts into the template the script information entered in screen **56**. For example, FIGS. 6A - 6B illustrate a sample script program created by script generator **50** from the script information shown in FIG. 5.

The script program includes display commands to display the queries and response choices entered in fields **94** and **96**, respectively. The script program also includes input commands to receive responses to the queries. The script program further includes a collect command to collect device measurements from the monitoring device specified in check boxes **98**. The script program also includes commands to establish a subsequent communication link to the server at the connection time specified in field **100**. The steps included in the script program are also shown in the flow chart of FIGS. 12A - 12B and will be discussed in the operation section below.

Referring again to FIG. 2, script assignor **52** is for assigning script programs **40** to the patients. Script programs **40** are assigned in accordance with script assignment information entered through workstation **20**. The script assignment information is entered through a script assignment screen **57**, which is preferably implemented as a web page on server **18**.

FIG. 7 illustrates a sample script assignment screen **57** as it appears on workstation **20**. Screen **57** includes check boxes **106** for selecting a script program to be assigned and check boxes **108** for selecting the patients to whom the script program is to be assigned. Screen **57** also includes an ASSIGN SCRIPT button **112** for entering the assignments. When button **112** is pressed, the script assignor creates and stores for each patient selected in check boxes **108** a respective pointer to the script program selected in check boxes **106**. Each pointer is stored in the patient look-up table of the database. Screen **57** further includes an ADD SCRIPT button **110** for accessing the script entry screen and a DELETE SCRIPT button **114** for deleting a script program.

Referring again to FIG. 2, report generator **54** is designed to generate a patient report **58** from the responses and device measurements received in server **18**. Patient report **58** is displayed on workstation **20**. FIG. 10 shows a sample patient report **58** produced by report generator **54** for a selected patient. Patient report **58** includes a graph **116** of the device measurements received from the patient, as well as a listing of responses **42** received from the patient. Specific techniques for writing a report generator program to display data in this manner are well known in the art.

The operation of the preferred embodiment is illustrated in FIGS. 1 - 12. FIG. 11A is a flow chart illustrating steps included in the monitoring application executed by server **18**. FIG. 11B is a continuation of the flow chart of FIG. 11A. In step **202**, server **18** determines if new script information has been entered through script entry screen **56**. If new script information has not been entered, server **18** proceeds to step **206**. If new script information has been entered, server **18** proceeds to step **204**.

As shown in FIG. 5, the script information includes a set of queries, and for each of the queries, corresponding responses choices. The script information also includes a selected monitoring device type from which to collect device measurements. The script information further includes a prescribed connection time for each apparatus to establish a subsequent communication link to the server. The script information is generally entered in server **18** by a healthcare provider, such as the patients' physician or case manager. Of course, any person desiring to communicate with the patients may also be granted access to server **18** to create and assign script programs. Further, it is to be understood that the system may include any number of remote interfaces for entering script generation and script assignment information in server **18**.

In step **204**, script generator **50** generates a script program from the information entered in screen **56**. The script program is stored in database **38**. Steps **202** and **204** are preferably repeated to generate multiple script programs, e.g. a script program for diabetes patients, a script program for asthma patients, etc. Each script program corresponds to a respective one of the sets of queries entered through script entry screen **56**. Following step **204**, server **18** proceeds to step **206**.

In step **206**, server **18** determines if new script assignment information has been entered through assignment screen **57**. If new script assignment information has not been entered, server **18** proceeds to step **210**. If new script assignment information has been entered, server **18** proceeds to step **208**. As shown in FIG. 7, the script programs are assigned to each patient by selecting a script program through check boxes **106**, selecting the patients to whom the selected script

program is to be assigned through check boxes **108**, and pressing the ASSIGN SCRIPT button **112**. When button **112** is pressed, script assignor **52** creates for each patient selected in check boxes **108** a respective pointer to the script program selected in check boxes **106**. In step **208**, each pointer is stored in look-up table **46** of database **38**. Following step **208**, server **18** proceeds to step **210**.

In step **210**, server **18** determines if any of the apparatuses are remotely connected to the server. Each patient to be monitored is preferably provided with his or her own apparatus which has the patient's unique identification code stored therein. Each patient is thus uniquely associated with a respective one of the apparatuses. If none of the apparatuses is connected, server **18** proceeds to step **220**.

If an apparatus is connected, server **18** receives from the apparatus the patient's unique identification code in step **212**. In step **214**, server **18** receives from the apparatus the query responses **42**, device measurements **44**, and script identification code recorded during execution of a previously assigned script program. The script identification code identifies to the server which script program was executed by the apparatus to record the query responses and device measurements. The responses, device measurements, and script identification code are stored in database **38**.

In step **216**, server **18** uses the patient identification code to retrieve from table **46** the pointer to the script program assigned to the patient. The server then retrieves the assigned script program from database **38**. In step **218**, server **18** transmits the assigned script program to the patient's apparatus through communication network **24**. Following step **218**, server **18** proceeds to step **220**.

In step **220**, server **18** determines if a patient report request has been received from workstation **20**. If no report request has been received, server **18** returns to step **202**. If a report request has been received for a selected patient, server **18** retrieves from database **38** the measurements and query responses last received from the patient, step **222**. In step **224**, server **18** generates and displays patient report **58** on workstation **20**. As shown in FIG. 10, report **58** includes the device measurements and query responses last received from the patient. Following step **224**, the server returns to step **202**.

FIGS. 12A - 12B illustrate the steps included in the script program executed by apparatus **26**. Before the script program is received, apparatus **26** is initially programmed with the patient's unique identification code and the script interpreter used by microprocessor **76** to execute the script program. The initial programming may be achieved during manufacture or during an initial connection to server **18**. Following initial programming, apparatus **26** receives from server **18** the script program assigned to the patient associated with apparatus **26**. The script program is received by modem **86** through a first communication link and stored in memory **80**.

In step **302**, microprocessor **76** assigns a script identification code to the script program and stores the script identification code in memory **80**. The script identification code is subsequently transmitted to the server along with the query responses and device measurements to identify to the server which script program was most recently executed by the apparatus. In step **304**, microprocessor **76** lights LED **74** to notify the patient that he or she has unanswered queries stored in apparatus **26**. LED **74** preferably remains lit until the queries are answered by the patient.

In step **306**, microprocessor **76** erases from memory **80** the last set of query responses recorded.

In step **308**, microprocessor **76** prompts the patient by displaying on display **64** "ANSWER QUERIES NOW? PRESS ANY BUTTON TO START". In step **310**, microprocessor **76** waits until a reply to the prompt is received from the patient. When a reply is received, microprocessor **76** proceeds to step **312**. In step **312**, microprocessor **76** executes successive display and input commands to display the queries and response choices on display **64** and to receive responses to the queries.

FIG. 8 illustrate a sample query and its corresponding response choices as they appear on display **64**. The response choices are positioned on display **64** such that each response choice is located proximate a respective one of the input buttons. In the preferred embodiment, each response choice is displayed immediately above a respective input button. The patient presses the button corresponding to his or her response. Microprocessor **76** stores each response in memory **80**.

In steps **314** - **318**, microprocessor **76** executes commands to collect device measurements from a selected monitoring device. The script program specifies the selected monitoring device from which to collect the measurements. In step **314**, microprocessor **76** prompts the patient to connect the selected monitoring device, for example a blood glucose meter, to one of the device jacks. A sample prompt is shown in FIG. 9. In step **316**, microprocessor **76** waits until a reply to the prompt is received from the patient. When a reply is received, microprocessor **76** proceeds to step **318**. Microprocessor **76** also connects UART **78** to interface **90** through switch **88**. In step **318**, microprocessor **76** collects the device measurements

from monitoring device **28** through interface **90**. The measurements are stored in memory **80**.

In step **320**, microprocessor **76** prompts the patient to connect apparatus **26** to telephone jack **22** so that apparatus **26** may connect to server **18** at the prescribed connection time. In step **322**, microprocessor **76** waits until a reply to the prompt is received from the patient. When a reply is received, microprocessor **76** turns off LED **74** in step **324**. In step **326**, microprocessor **76** waits until it is time to connect to server **18**. Microprocessor **76** compares the connection time specified in the script program to the current time output by clock **84**. When it is time to connect, microprocessor **76** connects UART **78** to modem **86** through switch **88**.

In step **328**, microprocessor **76** establishes a subsequent communication link between apparatus **26** and server **18** through modem **86** and communication network **24**. If the connection fails for any reason, microprocessor **76** repeats step **328** to get a successful connection. In step **330**, microprocessor **76** transmits the device measurements, query responses, script identification code, and patient identification code stored in memory **80** to server **18** through the subsequent communication link. In step **332**, microprocessor **76** receives through modem **86** a new script program from server **18**. The new script program is stored in memory **80** for subsequent execution by microprocessor **76**. Following step **332**, the script program ends.

One advantage of the monitoring system of the present invention is that it allows each patient to select a convenient time to respond to the queries, so that the monitoring system is not intrusive to the patient's schedule. A second advantage of the monitoring system is that it incurs very low communications charges because each remote apparatus

connects to the server at times when communication rates are lowest. Moreover, the cost to manufacture each remote apparatus is very low compared to personal computers or internet terminals, so that the monitoring system is highly affordable.

A third advantage of the monitoring system is that it allows each apparatus to be programmed remotely through script programs. Patient surveys, connection times, display prompts, selected monitoring devices, patient customization, and other operational details of each apparatus may be easily changed by transmitting a new script program to the apparatus. Moreover, each script program may be easily created and assigned by remotely accessing the server through the Internet. Thus, the invention provides a powerful, convenient, and inexpensive system for remotely monitoring a large number of patients.

FIGS. 13 - 15 illustrate a second embodiment of the invention in which each remotely programmable apparatus has speech recognition and speech synthesis functionality. FIG. 13 shows a perspective view of an apparatus **27** according to the second embodiment. Apparatus **27** includes a speaker **72** for audibly communicating queries and prompts to the patient. Apparatus **27** also includes a microphone **118** for receiving spoken responses to the queries and prompts. Apparatus **27** may optionally include a display **64** for displaying prompts to the patient, as shown in FIG. 14.

FIG. 15 is a schematic block diagram illustrating the components of apparatus **27** in greater detail. Apparatus **27** is similar in design to the apparatus of the preferred embodiment except that apparatus **27** includes an audio processor chip **120** in place of microprocessor **76**. Audio processor chip **120** is preferably an RSC-164 chip commercially

available from Sensory Circuits Inc. of 1735 N. First Street, San Jose, California 95112.

Audio processor chip **120** has a microcontroller **122** for executing script programs received from the server. A memory **80** is connected to microcontroller **122**. Memory **80** stores the script programs and a script interpreter used by microcontroller **122** to execute the script programs. Memory **80** also stores measurements received from monitoring device **28**, responses to the queries, script identification codes, and the patient's unique identification code.

Audio processor chip **120** also has built in speech synthesis functionality for synthesizing queries and prompts to a patient through speaker **72**. For speech synthesis, chip **120** includes a digital to analog converter (DAC) **142** and an amplifier **144**. DAC **142** and amplifier **144** drive speaker **72** under the control of microcontroller **122**.

Audio processor chip **120** further has built in speech recognition functionality for recognizing responses spoken into microphone **118**. Audio signals received through microphone **118** are converted to electrical signals and sent to a preamp and gain control circuit **128**. Preamp and gain control circuit **128** is controlled by an automatic gain control circuit **136**, which is in turn controlled by microcontroller **122**. After being amplified by preamp **128**, the electrical signals enter chip **120** and pass through a multiplexer **130** and an analog to digital converter (ADC) **132**. The resulting digital signals pass through a digital logic circuit **134** and enter microcontroller **122** for speech recognition.

Audio processor chip **120** also includes a RAM **138** for short term memory storage and a ROM **140** which stores programs

executed by microcontroller **122** to perform speech recognition and speech synthesis. Chip **120** operates at a clock speed determined by a crystal **126**. Chip **120** also includes a clock **84** which provides the current date and time to microcontroller **122**. As in the preferred embodiment, apparatus **27** includes an LED **74**, display driver **82**, modem **86**, and device interface **90**, all of which are connected to microcontroller **122**.

The operation of the second embodiment is similar to the operation of the preferred embodiment except that queries, response choices, and prompts are audibly communicated to the patient through speaker **72** rather than being displayed to the patient on display **64**. The operation of the second embodiments also differs from the operation of the preferred embodiment in that responses to the queries and prompts are received through microphone **118** rather than through user input buttons.

The script programs of the second embodiment are similar to the script program shown in FIGS. 6A - 6B, except that each display command is replaced by a speech synthesis command and each input command is replaced by a speech recognition command. The speech synthesis commands are executed by microcontroller **122** to synthesize the queries, response choices, and prompts through speaker **72**. The speech recognition commands are executed by microcontroller **122** to recognize responses spoken into microphone **118**.

For example, to ask the patient how he or she feels and record a response, microcontroller **122** first executes a speech synthesis command to synthesize through speaker **72** "How do you feel? Please answer with one of the following responses: very bad, bad, good, or very good." Next, microcontroller **118** executes a speech recognition command to

recognize the response spoken into microphone **118**. The recognized response is stored in memory **80** and subsequently transmitted to the server. Other than the differences described, the operation and advantages of the second embodiment are the same as the operation and advantages of the preferred embodiment described above.

Although the first and second embodiments focus on querying individuals and collecting responses to the queries, the system of the invention is not limited to querying applications. The system may also be used simply to communicate messages to the individuals. FIGS. 16 - 19 illustrate a third embodiment in which the system is used to perform this automated messaging function. In the third embodiment, each script program contains a set of statements to be communicated to an individual rather than a set of queries to be answered by the individual. Of course, it will be apparent to one skilled in the art that the script programs may optionally include both queries and statements.

The third embodiment also shows how the queries and statements may be customized to each individual by merging personal data with the script programs, much like a standard mail merge application. Referring to FIG. 16, personal data relating to each individual is preferably stored in look-up table **46** of database **38**. By way of example, the data may include each individual's name, the name of each individual's physician, test results, appointment dates, or any other desired data. As in the preferred embodiment, database **38** also stores generic script programs **40** created by script generator **50**.

Server **18** includes a data merge program **55** for merging the data stored in table **46** with generic script programs **40**. Data merge program **55** is designed to retrieve selected data

from table **46** and to insert the data into statements in generic script programs **40**, thus creating custom script programs **41**. Each custom script program **41** contains statements which are customized to an individual. For example, the statements may be customized with the individual's name, test results, etc. Examples of such customized statements are shown in FIGS. 17 - 18.

The operation of the third embodiment is similar to the operation of the preferred embodiment except that the script programs are used to communicate messages to the individuals rather than to query the individuals. Each message is preferably a set of statements. Referring to FIG. 19, the statements may be entered in the server through script entry screen **56**, just like the queries of the preferred embodiment.

Each statement preferably includes one or more insert commands specifying data from table **46** to be inserted into the statement. The insert commands instruct data merge program **55** to retrieve the specified data from database **38** and to insert the data into the statement. For example, the insert commands shown in FIG. 19 instruct the data merge program to insert a physician name, an appointment date, a patient name, and a test result into the statements. As in the preferred embodiment, each statement may also include one or more response choices which are entered in fields **96**.

Following entry of the statements and response choices, CREATE SCRIPT button **102** is pressed. When button **102** is pressed, script generator **50** generates a generic script program from the information entered in screen **56**. The generic script program is similar to the script program shown in FIGS. 6A - 6B, except that the display commands specify statements to be displayed rather than queries. Further, the statements include insert commands specifying data to be

inserted into the script program. As in the preferred embodiment, multiple script programs are preferably generated, e.g. a generic script program for diabetes patients, a generic script program for asthma patients, etc. The generic script programs are stored in database **38**.

Following generation of the generic script programs, server **18** receives script assignment information entered through script assignment screen **57**. As shown in FIG. 7, the script programs are assigned by first selecting one of the generic script programs through check boxes **106**, selecting individuals through check boxes **108**, and pressing the ASSIGN SCRIPT button **112**. When button **112** is pressed, data merge program **55** creates a custom script program for each individual selected in check boxes **108**.

Each custom script program is preferably created by using the selected generic script program as a template. For each individual selected, data merge program **55** retrieves from database **38** the data specified in the insert commands. Next, data merge program **55** inserts the data into the appropriate statements in the generic script program to create a custom script program for the individual. Each custom script program is stored in database **38**.

As each custom script program is generated for an individual, script assignor **52** assigns the script program to the individual. This is preferably accomplished by creating a pointer to the custom script program and storing the pointer with the individual's unique identification code in table **46**. When the individual's remote apparatus connects to server **18**, server **18** receives from the apparatus the individual's unique identification code. Server **18** uses the unique identification code to retrieve from table **46** the pointer to the custom script program assigned to the individual. Next,

server **18** retrieves the assigned script program from database **38** and transmits the script program to the individual's apparatus through communication network **24**.

The apparatus receives and executes the script program. The execution of the script program is similar to the execution described in the preferred embodiment, except that statements are displayed to the individual rather than queries. FIGS. 17 - 18 illustrate two sample statements as they appear on display **64**. Each statement includes a response choice, preferably an acknowledgment such as "OK". After reading a statement, the individual presses the button corresponding to the response choice to proceed to the next statement. Alternatively, the script program may specify a period of time that each statement is to be displayed before proceeding to the next statement. The remaining operation of the third embodiment is analogous to the operation of the preferred embodiment described above.

Although it is presently preferred to generate a custom script program for each individual as soon as script assignment information is received for the individual, it is also possible to wait until the individual's apparatus connects to the server before generating the custom script program. This is accomplished by creating and storing a pointer to the generic script program assigned to the individual, as previously described in the preferred embodiment. When the individual's apparatus connects to the server, data merge program **55** creates a custom script program for the individual from the generic script program assigned to the individual. The custom script program is then sent to the individual's apparatus for execution.

SUMMARY, RAMIFICATIONS, AND SCOPE

Although the above description contains many specificities, these should not be construed as limitations on the scope of the invention but merely as illustrations of some of the presently preferred embodiments. Many other embodiments of the invention are possible. For example, the scripting language and script commands shown are representative of the preferred embodiment. It will be apparent to one skilled in the art many other scripting languages and specific script commands may be used to implement the invention.

Moreover, the invention is not limited to the specific applications described. The system and method of the invention have many other application both inside and outside the healthcare industry. For example, pharmaceutical manufacturers may apply the system in the clinical development and post marketing surveillance of new drugs, using the system as an interactive, on-line monitoring tool for collecting data on the efficacy, side effects, and quality of life impact of the drugs. Compared to the current use of labor intensive patient interviews, the system provides a fast, flexible, and cost effective alternative for monitoring the use and effects of the drugs.

The system may also be used by home healthcare companies to enhance the service levels provided to customers, e.g. panic systems, sleep surveillance, specific monitoring of disease conditions, etc. Alternatively, the system may be used to monitor and optimize the inventory of home stationed health supplies. As an example, the system may be connected to an appropriate measuring device to optimize timing of oxygen tank delivery to patients with COPD.

The system and method of the invention also have many applications outside the healthcare industry. For example, the system may be used for remote education over the

Internet, facilitating educational communication with children or adult trainees who lack access to sophisticated and expensive computer equipment. The system may also be used by law enforcement officers to perform on-line surveillance of individuals on probation or parole.

Further, the invention has numerous applications for gathering data from remotely located devices. For example, the system may be used to collect data from smart appliances, such as identification check systems. Alternatively, the system may be applied to the remote monitoring of facilities, including safety and security monitoring, or to environmental monitoring, including pollution control and pipeline monitoring. Many other suitable applications of the invention will be apparent to one skilled in the art.

Therefore, the scope of the invention should be determined not by the examples given, but by the appended claims and their legal equivalents.